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Surface exposure dating with cosmogenic 10Be of Late Holocene rock avalanches onto glaciers in the Mont Blanc massif, Italy

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Rock avalanching represents a potential high risk for growing infrastructure and people living in high mountain areas. This hazardous process is due to steep slopes, high relief, intensive rock fracturing, seismicity, paraglacial control, periglacial climatic conditions and the presence and interaction of snow, glaciers, and permafrost. The timing of rock avalanche recurrence intervals and the recognition of their spatial extension are essential.
Very steep and elevated slopes on the Italian flank of the Mont Blanc massif are prone to rock avalanches (RAs) which travel onto glaciers. Whereas small RAs occurred in the Glacier du Miage basin during the 20th Century (the latest in July 2012), large RAs (volume > 1 M m3) travelled repeatedly onto Glaciers de Triolet, Frébouge, and la Brenva during the late Holocene
The nature of the granitic deposit which largely overlaps the bottom of the upper Val Ferret over 2 km has been discussed since the 19th century. This extensive deposit was attributed to either glacial, or a September 12th 1717 AD rock avalanche, or a complex mixture of glacial, earlier RA and 1717 RA origin. Surface exposure dating of 16 boulders of the deposit shows that the 1717 RA, covering the whole upper Ferret valley floor, was one of the largest late Holocene RAs of the Alps, with a rock volume of 10-15 M m3 and a likely similar volume of glacier ice travelling more than 7 km downvalley.
Two main RA deposits are lying downstream of the Glacier de Frébouge: a sheet of granite boulders with an open-work structure covers the south side of the Val Ferret, which ran > 100 m up the opposite metasedimentary side of the valley; a smaller RA deposit is located at the south and east margins of the large Frébouge polygenic fan. Surface exposure dating of 7 granite boulders of these deposits could in particular confirm whether the larger RA occurred sometime between 991 and 1154 AD, as suggested by a radiocarbon-dated piece of wood.
Large RAs (volume > 2 M m3) travelled onto the Glacier de la Brenva in 1920 and 1997 AD and reached the valley floor. Historical, geomorphological evidence, radiocarbon dating and lichenometry suggest a high RA frequency during the Late Holocene. RAs as large as 20th Century RAs are dated to: shortly before 1767 AD; the 14th Century; the early Middles Ages; and (indirectly) around 2.5 ka BP. Surface exposure dating of 15 granite boulders in deposits lying outside the 1920 deposit and on the opposite side of the Val Veny confirm both the extension and the dating of the 14th Century and c. 2.5 ka BP RAs.
As already underlined by Porter and Orombelli in the 1980s, the importance of large RAs has to be emphasised to help prevent major risk induced by this highly destructive process in highly anthropomorphic valleys. In this perspective, and even for the most recent period, the contribution of surface exposure dating to the geomorphological analysis of landslide/moraine complex is valuable – especially where landform assemblages are complex.